CARBON MONOXIDE AND THE BLOOD DONOR

James Williams, et al

Army Medical Research Laboratory
Fort Knox, Kentucky

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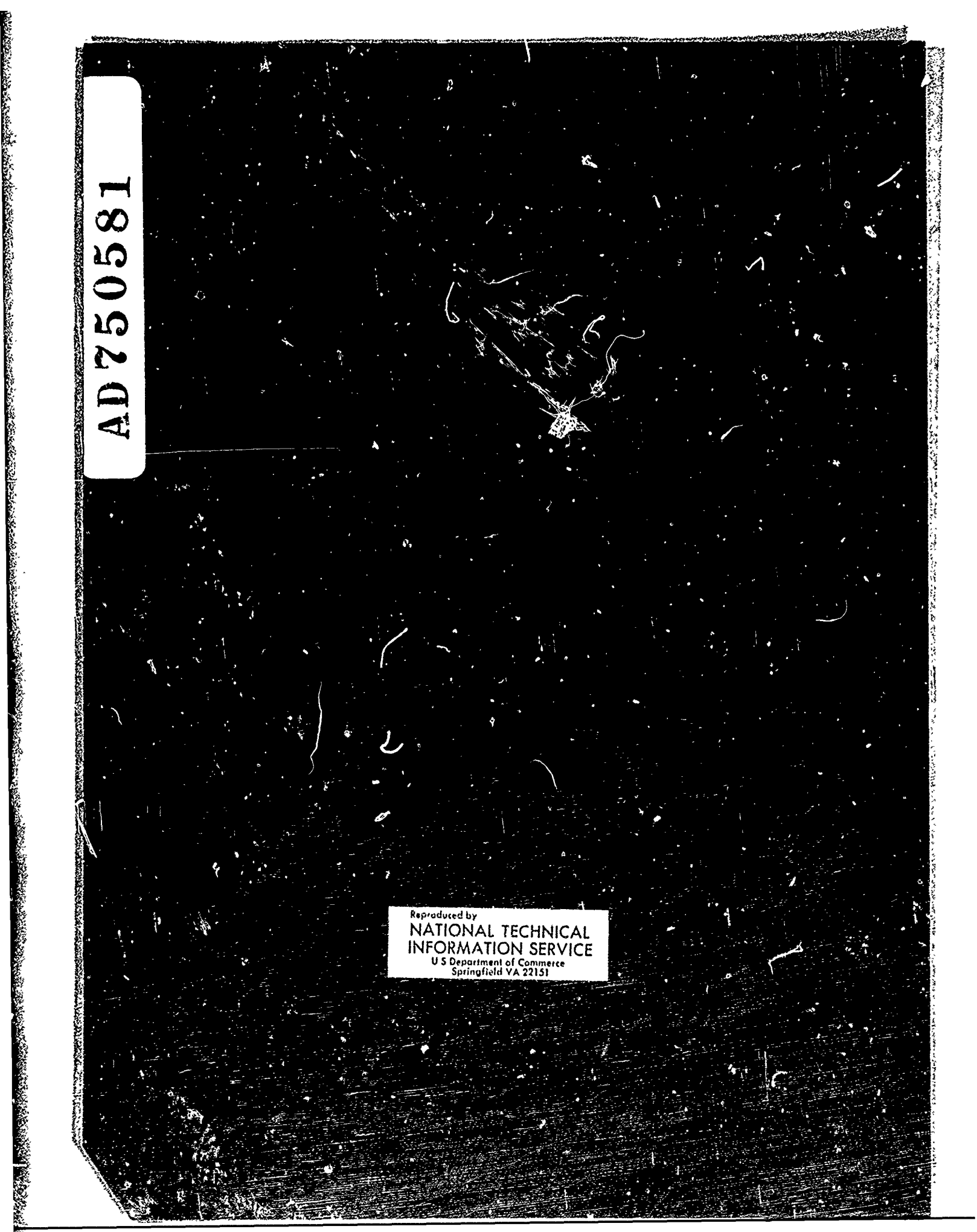

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13. ABSTRACT

Blood donors can significantly elevate their blood carbon monoxide (CO) level by smoking prior to donation. Binding of CO to hemoglobin is stronger than for oxygen so that there is a competitive loss of oxygen carrying capacity. CO levels tend to respond to the balance of oxygen and CO concentrations, so that normally a slow exchange with the room air will result in a decrease in the acutely-increased CO level caused by smoking. In volunteer studies wherein smoking was followed by hyperventilation with oxygen (100%) or a bout of exercise, CO levels decreased to a greater degree than in smokers not hyperventilated. Blood donors were subjected to a 3-4 min exercise prior to donation; CO level was found to have decreased more than in smokers who did not exercise, despite the observation that the CO level in non-smokers tended to rise after donation. In addition, a greater number of subjects demonstrated a decrease in CO with exercise compared with other smoker or nonsmoker groups who did not exercise.

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(Final Report)

by

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and

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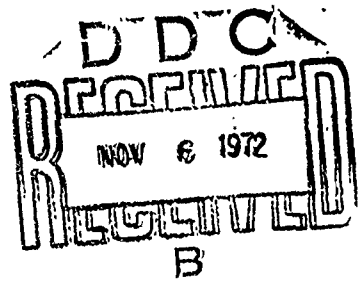

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Preservation Methods--Liquid and Frozen--and Logistics
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USAMRL REPORT NO. 993
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ABSTRACT

CARBON MONOXIDE AND THE BLOOD DONOR

OBJECTIVE

To study the effects that carbon monoxide (CO) caused by smoking has upon donor blood. Binding of CO to hemoglobin is 210 times greater than binding of oxygen so that there is a competitive loss of oxygen carrying capacity.

METHODS

After separating the donors into two groups, smoker and nonsmoker, the donors proceeded through routine processing until just prior to lying down on the donor table. At that point, based on random selection, some of the donors were asked to exercise for 3-4 min. A body bend exercise, arms fully extended, was used. Base line blood samples were collected from both groups prior to the exercise point and before donation.

CONCLUSIONS

Donors who admitted smoking shortly before donation showed a clear-cut elevation of their base line blood CO levels, and these levels consistently decreased after donation. The decrease of 10% in those that exercised prior to donation was more marked, compared to the 5% decrease in those smokers not exercising. Measures, such as exercise-induced hyperventilation, can be used in an effort to assure the lowest possible level of CO, thus improving the quality of blood for the recipient.

CARBON MONOXIDE AND THE BLOOD DONOR*

INTRODUCTION

The level of carbon monoxide (CO) in donor blood can be significantly elevated by smoking prior to donation. Binding of CO to hemoglobin is 210 times stronger than for oxygen so that there is a competitive loss of oxygen carrying capacity. CO levels respond to the balance of oxygen and CO concentrations, so that normally a slow exchange with room air will result in a decrease in the acutely increased CO level caused by smoking. In previous volunteer studies wherein smoking was followed by hyperventilation or inhalation of 100% oxygen, CO levels decreased to a greater degree than in smokers not hyperventilated. In the present study, blood donors were subjected to a 3-4 min bout of exercise prior to donation to determine if CO levels would decrease more in smokers than nonsmokers, with or without exercise.

METHOD

Each donor entering the center was interviewed to determine whether or not he had smoked and how recently. Those stating that they had not smoked in the past 24 hours--or never smoked--were placed in the group called "nonsmoker;" the others who admitted smoking were classified as "smokers." Additional information was obtained on the timing of the last cigarette using three categories: those who had smoked 1/2 hr, 1 hr, or more than 1 hr preceding the interview.

After separation into the two groups, smoker or nonsmoker, the donors proceeded through the routine processing until just prior to lying down on the donor table. At that point, based on random selection, some of the donors were asked to exercise for 3-4 min. A body bend exercise, arms fully extended, was used.

Base line blood samples were collected from both groups prior to the exercising point and before donation. Samples were collected from both groups after the bag units were collected. All samples for gas analysis were collected in Vacutainer tubes containing 7.0 ml ammonium and potassium oxalate. These tubes were withdrawn from the Vacutainer needle prior to withdrawing the needle from the puncture site to minimize the possibility of contamination of the samples by CO from room air. Needles used were the multisample type. Immediately after proper mixing and labeling, the samples were placed in an ice bath inside a refrigerator at 4°C until transferred to the blood gas analysis laboratory for testing the same day.

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*Presented at the 23rd Annual Meeting of the American Association of Blood Banks, San Francisco, California, 26-30 October 1970.

The study comprised 112 donors, 79 of whom were "smokers," and 28 of these exercised before donating. The remaining 33 subjects, the "nonsmoker" group, were divided randomly so that 17 exercised and 16 did not.

RESULTS

In the smoker category, the CO base line level for the exercise group averaged 4.1% and the base line level for the nonexercise group averaged 4.4% (Table 1). In the exercise group, there was an average change of -.4%, as compared to the nonexercise group's -.2%. The significant level of the exercise group was $p < .001$ and $p < .01$ for the nonexercise group. A 10% decrease for the exercise group was noted as opposed to the nonexercise group. Seventy-nine percent of the donors exercised showed a decrease, with a fall in 69% of the nonexercised donors.

TABLE 1

Donor (Smoker) Carbon Monoxide (CO)

	Exercise Group	Nonexercise Group
Number of subjects	28	51
Base line average	4.1%	4.4%
Average change after donation	-.4%	-.2%
Base line average change significance	$p < .001$	$p < .01$
Decrease after donation	10%	5%

The average base line CO level in the nonsmoker category was 1.7% for those exercising, and 1.8% for those not exercising (Table 2). After donation, an average change of +.2% for the exercised group and +.1% for the nonexercised group in the nonsmoker category was observed. The average increase in the CO level in the nonsmoker group is in contrast to the average decrease in the smoker group. However, it was noted that some of the nonsmoker subjects did have individual decreases, which consisted of only 29% of the exercised group and 37% of the nonexercised group.

TABLE 2

Donor (Nonsmoker) Carbon Monoxide (CO)

	Exercise Group	Nonexercise Group
Number of subjects	17	16
Base line average	1.7%	1.8%
Average change after donation	+.2%	+.1%

Other sources of CO were considered. Since the donors arrived at the donor center by bus, the buses and area were checked for possible CO contamination, using a Colorimetric Sampling Pump with indicator tubes. These tests revealed no CO contamination inside the bus or other areas.

DISCUSSION

The greater affinity of hemoglobin for CO, compared to oxygen, can lead to serious physiological consequences. Smoking is a ready source for CO; it can increase the CO content in the lungs with a resulting increase in carboxyhemoglobin. This common occurrence, combined with the loss of the ability of stored blood to release oxygen properly, can compromise the overall oxygen carrying capacity of bank blood. Fortunately, the displacement of oxygen by CO responds to the physical gas laws and, by increasing the oxygen concentration, the hemoglobin binding is reversed; hence, the rationale for the use of oxygen in the treatment of CO poisoning.

This principle has been applied in a trial with volunteers who had been exposed to mild increases of CO associated with extremely heavy smoking. These volunteers were treated in two ways: hyperventilation to increase ventilatory exchange, or by breathing oxygen to increase the oxygen level. During these studies, the rate of excretion of the CO was observed. No significant difference was found between those exercising or using oxygen.

When these principles were considered for use in a routine operating blood bank, the safety hazard of using oxygen led to emphasizing hyperventilation. The volunteers in the initial study were well-motivated and cooperative and voluntary hyperventilation was readily achieved. In the routine operation of a donor center it was anticipated that such cooperation and motivation would be considerably less. To partially

obviate this problem, exercise was used to stimulate hyperventilation and the exercise chosen was carried out for at least 3 min, but did not exceed 4 min. The exercise consisted of deep body bends and was chosen because it was quiet, could be done in one place, could be easily monitored, and because it was felt to cause a greater movement of the diaphragm, thus aiding ventilatory exchange. The result was a definite increase in pulse and respiratory rate, but no apparent increase in oxygen debt, or acidosis.

The fall in CO blood levels observed in smokers, compared to a rise in the nonsmokers, is, in part, the result of the natural exchange with room air after smoking was stopped. The change in the exercised, compared to the nonexercised, smoker was more striking, suggesting that induced hyperventilation was effective.

The need to improve the overall quality of blood being collected should consider, among other things, the removal of temporary toxic factors, such as CO. This undesirable condition may be avoided by asking prospective donors not to smoke for 2 or more hr before donation; otherwise, more active measures, such as exercise-induced hyperventilation, can be used in an effort to assure the lowest possible level of CO, thus improving the quality of blood for the needy recipient.

SUMMARY

In these studies, the CO level in nonsmokers was observed to rise slightly after donation—an observation that is unexplained. In contrast, donors who admitted smoking shortly before donation showed a clear-cut elevation of their base line blood CO levels, and these levels consistently decreased after donation. A decrease of 10% in those that exercised prior to donation was more marked compared to the 5% decrease in those smokers not exercising. Thus, individual donors who had been smoking shortly before donation would be able to decrease their CO levels by brief exercise prior to donation.